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LIFE CYCLE MANAGEMENT

Life cycle assessment and eco-efficiency analysis of drinking cups used at public events

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Abstract

Background, aim, and scope At the request of the Public Waste Agency for the Flemish Region, the Flemish Institute for Technological Research performed a life cycle assessment (LCA), according to the International Organization for Standardization (ISO) 14040 procedures (ISO 1997, 1998, 2000, and ISO 2006), followed by an eco-efficiency analysis of four alternative types of drinking cups for use at public events. The results of the LCA study served as input for the eco-efficiency analysis in which the costs related to the four cup systems were studied and combined with the environmental impacts. The objective of this study was to gain insight into the current environmental impacts and costs related to existing systems for drinking cups at public events in Flanders (Belgium) in order to outline a well-founded policy with regard to this subject. Since the results of this comparative study are publicly available, a critical review was performed according to ISO 14040 (review by interested parties, using a review panel) after each stage (goal and scope, data inventory, impact analysis/ interpretation, eco-efficiency analysis) during the study.

Methodology Four types of cups were analysed; the reusable polycarbonate cup (PC), the one-way polypropylene cup (PP), the one-way PE-coated cardboard cup and the one-way polylactide cup (PLA). The functional unit is defined as ‘the recipients needed to serve 100 l of beer or soft drinks at a small-scale indoor respectively a large-scale outdoor event’. This definition included the production of the cups, the consumption stage (at the event) and the processing of the waste. The data inventory focused on specific data supplied by different stakeholders in Flanders (and Belgium). Based on data collected for specific events, an average typical small indoor and large outdoor event was defined, respectively. One important aspect in this context was the trip rate for the reusable cups, meaning the average number of times one cup can be used before disposal. Based on practical experiences combined with literature research, a trip rate was defined for small- and large-scale events, respectively. Since this factor was very important but also very open for debate, a sensitivity analysis was performed on the trip rate. The impact analysis was based on the Eco-Indicator 99 methodology (Hierarchist version H/A; Goedkoop and Spriensma 2000). The main reason for using this methodology was that it allows the calculation of one weighted environmental indicator for each alternative, which was needed as input for the eco-efficiency analysis. The cost indicator, which was based on similar system boundaries and assumptions as the environmental indicator, was calculated from a societal perspective. Both indicators were combined in an eco-efficiency portfolio, with the average in the centre point and the number of standard deviations indicated on the axes.

Results and discussion For the environmental profile of the individual cup systems, the total life cycle of the cups was divided in different life cycle stages. Based on the individual profiles it could be concluded that the most important environmental contribution when using reusable PC cups at small indoor events is caused by the production

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of the cups and the transport of the cups from the distributor to the event and back. On large outdoor events, the (machine) cleaning of the cups also contributes significantly to the total environmental impact. For one-way cups (PP, PE-coated cardboard and PLA) used at small indoor as well as large outdoor events, the production of the cups dominates the environmental profiles. By comparing the environmental impacts of the four types of cups on both types of event, it became clear that none of the cup systems has the highest or the lowest environmental score for all environmental impact categories considered in the study. Based on these comparisons, it was not possible to make a straightforward conclusion for the selection of the most favourable cup system with regard to the environment. When comparing the individual cup systems between small indoor and large outdoor events, the reusable PC cup differs the most between both types of events. The environmental burden increases significantly for PC cups moving to larger scale events. This can be explained by the lower trip rate and the machine cleaning instead of manual cleaning of the cups after large events. For the other types of cup systems, the difference going from a small to a large scale event is negligible. The combination of the environmental and cost indicator in the eco-efficiency analysis led to a different result for small indoor compared to large outdoor events. The eco-efficiency portfolio for small events showed that the reusable PC cup has a significant more favourable environmental score than the one-way cups, but the cost indicator is significantly higher. This may be an argument to initiate a promotion policy for reusable PC cups at small events. For large events, the eco-efficiency portfolio did not result in a significant winner with regard to the environmental or cost indicator. To determine the influence of a change in the inventory data on the results of the impact assessment and eco-efficiency analysis, some sensitivity analyses were performed, for example for a variation in trip rate, a variation in the cleaning of the cups during and after the event (manual versus machine), and a future scenario for the PLA cups (change in production process, end-of-life treatment, etc.).

Conclusions The comparative LCA study according to ISO did not provide an overall environmentally superior cup system. In the eco-efficiency analysis, using a subjective weighting step, the reusable PC cup system resulted to be significantly better compared to the other cup systems for small events from an environmental point of view. Two aspects that improved the overall quality of this study are on the one hand the consultation and collaboration of the stakeholders during the process to supply information, check the inventory data and give feedback on the preliminary results and on the other hand the work of the review panel in order to ensure that the provisions from the ISO 14040 series regarding methods, data, interpretations and reporting are taken care of. It was appreciated by the commissioner and all stakeholders that the results of the study are communicated in a transparent way, with a discussion of the necessary differentiations.

Recommendations and perspectives From the comparative LCA-study according to ISO, none of the four considered cup systems has overall superior or inferior performance neither at small nor large events. This means that there are no scientific arguments for a policy of encouraging or discouraging one of the four cup systems based on the LCA-results. The eco-efficiency assessment (with its subjective choices and limitations, that the commissioner of the study should realise and support in the context of this study) has shown that in the base case for small events the PC cup system shows a significant more favourable environmental score than the other three cup systems on the market. As the costs of the reusable PC cup system are higher, a policy of promoting the system can be considered based on the more favourable environmental score. Policy makers should agree on the subjective value choices made while weighting different impact or damage categories.

Keywords Drinking cups · Eco-efficiency · External review · Life cycle assessment (LCA) · PC · PE · Polylactide (PLA) · PP · Single use · Re-use

1 Introduction

In the Flanders Region of Belgium more than 100,000 events are organised annually, of which approximately 200 are large events (i.e., more than 10,000 visitors). This results in a huge amount of waste, the majority of which is coming from discarded drinking cups. Since 2002, the Public Waste Agency for the Flemish Region (OVAM) stimulates the use of reusable cups on events. This has proved to be quite successful for small events; however, the use of reusable cups at large events encountered some difficulties and for this reason has not been widely introduced. The introduction at events of the biodegradable cup made of polylactic acid (PLA) could be a one-way alternative for the reusable cups from an environmental point of view. For this reason, OVAM commissioned the Flemish Institute for Technological Research (VITO) to thoroughly analyse and compare the environmental impacts when using different types of drinking cups at events. The life cycle assessment was extended with an eco-efficiency analysis to enable a well-founded governmental policy decision in this regard. The full study was performed in accordance with the International Organization for Standardization (ISO) 14040 procedures that were available at that time (ISO 1997, ISO 14041, 1998, ISO 14042, 2000 and ISO 2006). As OVAM requested the results of the study to be publicly available, a critical review by TNO and

a review panel took place in parallel to the study. This paper discusses the approach and the results of the life cycle assessment (LCA) as well as the eco-efficiency study, and summarises the main conclusions.

2 Life cycle assessment of drinking cups used at events

2.1 Goal and scope definition

The functional unit is defined as “the recipients needed to serve 100 liters of beer or soft drinks at a small-scale indoor (2,000-5,000 visitors) and a large-scale outdoor event (>30,000 visitors)”. This definition includes the production of the cups, the consumption stage (at the event) and the processing of the cup waste. The categorization into ‘small’ and ‘large’ events stemmed from the consideration that both types of events differ largely, particularly with regard to organisational issues (professional versus voluntary) and waste collection. The option to distinguish also between indoor and outdoor events was mainly prompted by the differences regarding the available facilities (water supply, sewage system, etc.).

Four different cups, used in the Flanders Region of Belgium, were considered: the reusable cup in polycarbonate (PC), the one-way cup in polypropylene (PP), the one-way cup in polyethylene (PE) coated cardboard, and the one-way cup in PLA. As the PC cups were the only reusable cups used in Flanders, no alternative reusable cups were considered. With regard to the drinking volume, the 25 cl (which relates normally to 33 cl total volume) was identified as being the most representative.

Contrary to environmental data, cost data were only available at the aggregated level and thus no streamlining was applied for the LCA, since the extension with the eco-efficiency analysis required similar system boundaries for both analyses. All life cycle stages, from the extraction of raw materials to the final waste treatment, were considered.

2.2 Inventory analysis

Since the initial objective was to use data specific to the Flanders Region of Belgium, the data inventory was based on an inquiry among different stakeholders. Only for stages for which no specific data were available, more general data were taken from literature. For the (rare) aspects where no specific or general data existed an assumption was made, based on expert judgement, no case-specific data were taken for modelling both the small-scale indoor and the large-scale outdoor event; but all data reflecting the respective visitors numbers were averaged to result in one generic small indoor respectively large outdoor event.

With respect to the inventory of data, the difference between one-way and reusable cups was an important issue. Assuming a 25 cl drinking volume, 400 one-way cups are needed in relation to the functional unit of 100 l. This relation is less well-defined for reusable cups and depends on the number of times one cup is reused at one event. In this study, it was considered that 160 reusable cups are needed for serving 100 l beer or soft drinks during one event. This is based on the assumption that one reusable cup is used on average 2.5 times during one event.

An important and uncertain element in the data inventory was the definition of the trip rate of the reusable cups. The trip rate is defined as the number of times one cup can be used (on average) over its entire life. In the study, the trip rate is defined from the perspective of the cup and its use over a number of events, not on one specific event. The determination of the trip rate is based on an inventory of literature data, practical experiences in Belgium, and an inquiry among stakeholders. As such, the trip rate is defined in a basic scenario as follows: 45 trips per cup at small-scale indoor events, 20 trips per cup at large-scale outdoor events. The different trip rate between both event types is due to factors like type of event, type of public, return system, and organiser’s objectives (cup management by professional rental organisation instead of event organiser), which are better manageable in case of small indoor events.

Because of the uncertainty of the trip rate, a worst case trip rate (14 for small indoor, seven for large outdoor events) and a best-case trip rate (100 for small indoor and 40 for large outdoor events) were defined and assessed in a sensitivity analysis.

In general, the study starts from a basic scenario but for the most uncertain and the most relevant parameters sensitivity analyses were performed additionally. Figure 1 shows the overall life cycle of the cups that is taken into account.

The basic end-of-life scenario of the cups is defined as follows: 50% incineration in a municipal solid waste incinerator (MSWI) and 50% co-combustion in a cement kiln (for PP- and cardboard cups), 50% incineration in a MSWI and 50% composting (for PLA-cups), 100% incineration in a MSWI (for reusable PC cups that ultimately have reached their end of useful life).

2.3 Impact assessment and interpretation

The impact assessment was performed according to the Eco-Indicator 99 methodology (Hierarchist version, H/A) (Goedkoop and Spriensma 2000). Table 1 presents the environmental impact categories that are considered in this study.

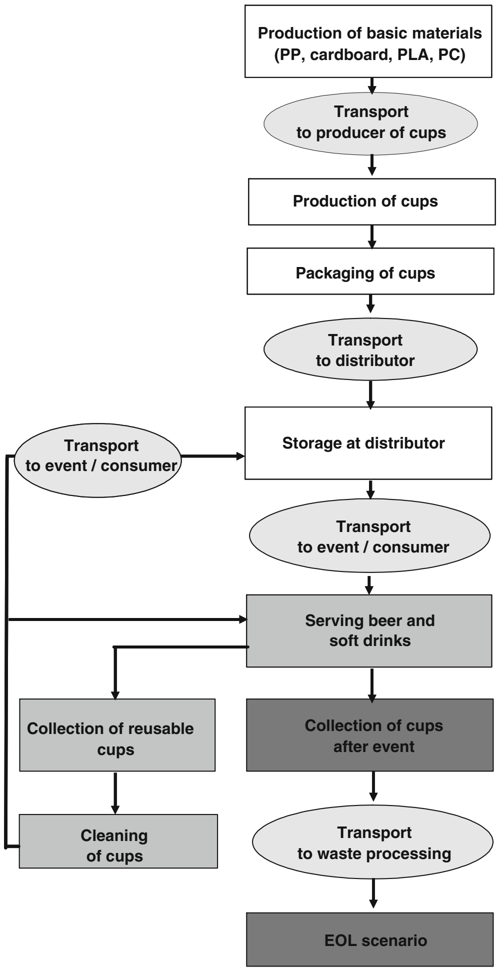

Fig. 1 General life cycle tree for the use of cups on events

2.3.1 Individual environmental profiles

The analysis of each cup type individually was not the initial objective of the study; however, this often leads to better insight in and clarification of the comparison of the cups. The individual profiles showed that the most important environmental contribution when using reusable PC cups at small-scale indoor events is caused by the production of the cups and the transport of the cups between the distributor and the event site (both there and back). For one-way cups used at small-scale indoor events, the production of the cups dominates the environmental profile.

For large-scale outdoor events, the individual profiles of the one-way cups are very similar to the small-scale indoor events. The environmental profile of the reusable PC cups however, differs largely with that of the small-scale events. In case reusable PC cups are used at large events, the environmental profile is dominated by the production of the cups and the cleaning of the cups after the event. This already indicates that the conclusions of the environmental comparison of the four types of cups could depend on the scale and location of the event.

Table 1 Impact categories considered in this study

Environmental impact categories	Unit
Carcinogenics	DALY
Respiratory effects caused by organics	DALY
Respiratory effects caused by inorganics	DALY
Climate change	DALY
Ozone layer	DALY
Ecotoxic emissions	PAF*m²*yr
Acidification / eutrophication	PDF*m²*yr
Extraction of minerals	MJ surplus
Extraction of fossil fuels	MJ surplus

2.3.2 Comparative environmental profiles

The primary goal of the study was to compare different types of cups used at public events. Figure 2 presents the comparative environmental profiles for small-scale indoor respectively large-scale outdoor events. The comparison is presented in a diagram in which the cup type with the highest contribution to a particular environmental effect is indicated with a 100% bar. Within this figure, the other types of cups are expressed as a percentage of the type of cup with the highest contribution.

For both types of events, we could conclude that none of the cup systems has the highest or the lowest environmental score for all impact categories considered. Whereas, for example, the PP cups life cycle for small indoor events is the most favourable concerning the depletion of minerals, it has at the same time the highest contribution for climate change. It is not possible to compare contributions to the various environmental impact categories with each other because these are expressed in different units. Because of this, no straightforward conclusion could be taken for the selection of the most favourable cup with regard to the environment. By comparing individual cup systems between small indoor and large outdoor events, the reusable PC cup differ the most between both types of events. For small indoor events, the reusable PC cup never has the highest score while for large outdoor events, this cup has the highest score for ozone layer depletion and approaches the highest score for climate change. So the environmental burden increases significantly for reusable PC cups moving to larger scale events. This can be explained by the lower trip rate and the machine cleaning instead of manual cleaning of the cups after the event. Manual cleaning causes less environmental impact due to lower water consumption, no electricity consumption, and no additional transport to bring the cups from the event site to the

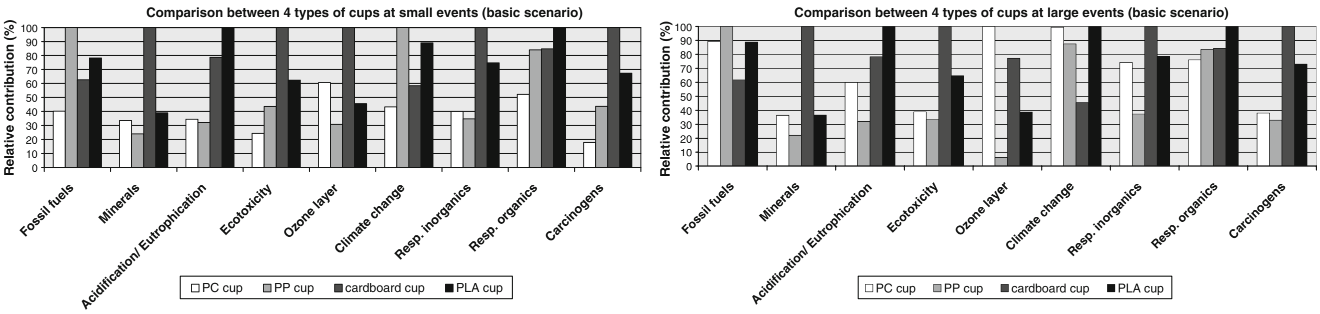

Fig. 2 Comparative environmental profiles for small-scale indoor and large-scale outdoor events, respectively

cleaning location. For the other types of cups, the difference going from a small to a large scale event is negligible.

By normalisation, the environmental impacts of the cup systems were related to the impact of economic activities in a specific region over a specific time period. For this study, normalisation has been performed at the damage category level (endpoint level in ISO terminology) on a European scale (damage caused by one European per year; Goedkoop and Spriensma 2000). Figure 3 presents the normalised comparative environmental profiles for both types of events. These show that for all cups, the contribution to the depletion of fossil fuels is large, relative to the background load per person applied as a normalisation reference. In addition, the contribution to respiratory effects on humans caused by inorganic substances cannot be neglected. However, even when considering only these three most relevant damage categories, a clear and straightforward conclusion with regard to the least environmentally harmful cup system could not be drawn, based on these normalised profiles.

2.3.3 Sensitivity analyses

Sensitivity analyses were performed to determine the influence of a change in the inventory data on the results of the impact assessment. A first sensitivity analysis assessed the influence of the trip rate for reusable cups (for both small indoor and large outdoor events), the amount of water and soap used for the cleaning during the event, and the cleaning of the cups after the small indoor event (by machine instead of by hand). The analysis confirmed that the trip rate was a sensitive factor. For both small indoor and large outdoor events, the trip rate had a clear effect on the ranking of the different cup types per impact category. The sensitivity analysis also confirmed that the use of double as much water compared to the basic scenario and extra soap did not have a significant influence on the individual environmental profile of the reusable cups nor on the comparison with the one-way cup types. A sensitivity analysis that focussed on different end-of-life scenarios showed that these only lead to different results for the PP and cardboard cups. When a higher percentage of PP and cardboard cup waste is going to a cement kiln, the total environmental contribution of the respective cup system decreases. However, the overall conclusion on the comparison of the four cup systems still applies.

The PLA cup is a relatively new development compared to the other cups. A sensitivity analysis was performed to evaluate the impacts of the use of PLA cups once the PLA production system is more mature. This demonstrated that the estimated future scenario for the PLA cups (PLA next generation; NG) has a

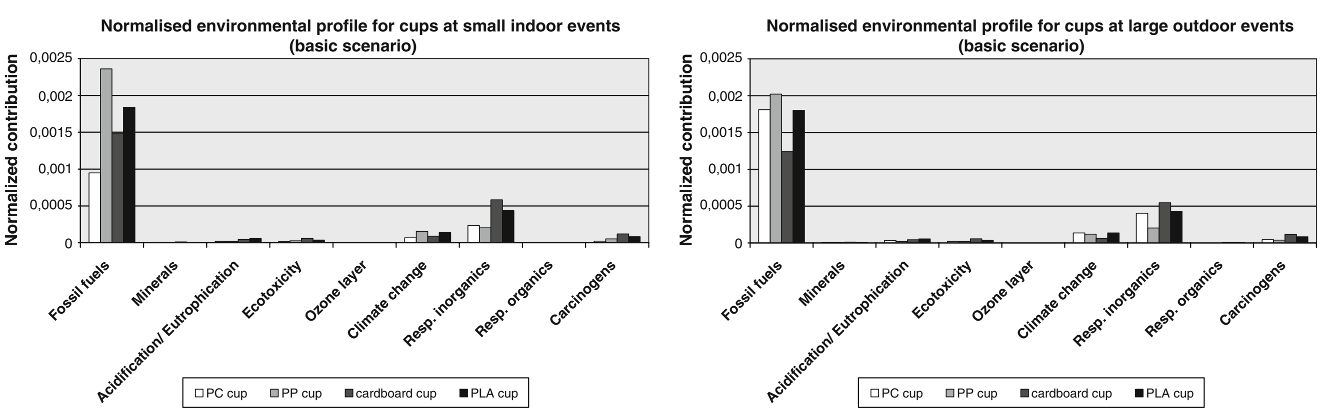

Fig. 3 Normalised environmental profiles for small-scale indoor and large-scale outdoor events, respectively

significant influence on the environmental profile of the PLA cup. Depending on the environmental impact category, the impact of the PLA cup's life cycle can decrease with 10-60%. One important factor for this decrease is the lower cup weight, which was at the time of the study a short term option that is already realised in 2007. The reduction of the weight of the PLA cup with 15% causes a proportional decrease of the environmental contribution of the PLA cup's life cycle. The other potential improvements were estimation and should be assessed again once they are realised in the future.

2.4 Conclusions of the LCA

As the LCA study was used to support a comparative assertion that is disclosed to the public, according to the ISO 14040, the evaluation needed to be presented category indicator by category indicator. For both types of events, it could be concluded that none of the cup systems had the highest or the lowest environmental score for all environmental impact categories considered in the study. Based on these comparisons, we were not able to draw a straightforward conclusion for the selection of the most favourable cup system with regard to the environment taking into account the ISO requirements (ISO 2006).

When comparing individual cup systems between small indoor and large outdoor events, the largest differences occur for the reusable PC cup. At small indoor events, the PC cup never has the highest impact. For large outdoor events, the PC cup has the highest score for ozone layer depletion and approaches the highest score for climate change. So the environmental burden increases significantly for PC cups moving to larger scale events. This can be explained by the lower trip rate and the machine cleaning instead of manual cleaning of the cups after the event. For the other types of cup systems, the differences observed, going from a small to a large-scale event, were negligible.

From this comparative LCA study according to ISO, none of the four considered cup systems has overall superior or inferior performance neither at small nor large events since no cup system scores best or worst on all impact categories. As a consequence, no scientific arguments exist for a policy of encouraging or discouraging one of the four cup systems. A policy development would need subjective values in its decision process.

Of course the results of a LCA are specifically related to the environmental aspects of the different cup systems. The environment is only one of the factors that constitute a well-founded policy with regard to the use of cups at events, even if it concerns an environmental policy. It is for example very important to also consider safety and hygienic aspects in this regard.

3 Eco-efficiency analysis of drinking cups used at events

3.1 Calculation of the environmental indicator

The LCA results were the basis for the calculation of the environmental indicator. ISO emphasises that the calculation of one subjective single environmental indicator within a comparative LCA study disclosed to the public is not allowed (ISO 2006). However, this part of the study formed part of an eco-efficiency analysis. No ISO standards for eco-efficiency studies exist. Nonetheless, VITO performed this eco-efficiency study following the same procedural steps of the ISO1404x series, but used subjective weighting to create a single environmental indicator.

Various methods are available to calculate the contribution to the different environmental damage categories further into one environmental indicator. All these methods need some kind of weighting principle to give weight to different environmental aspects in order to calculate one single environmental indicator. These methods are not fully scientific and objective, and based on subjective choices. The weighting in this study was based on weighting factors from a Dutch report on Eco-Indicator 99 (Goedkoop and Spriensma 2000). The hierarchical version of the method was chosen, using the average set of weighting factors. The other two perspectives (individual and egalitarian) were used to indicate robustness within a sensitivity analysis.

The eco-indicator 99 (EI-99) values for the use of one way cups (PP, PE coated, and PLA cups) at small indoor events are very much comparable to each other (Fig. 4). For defining the significance of differences in EI-99 values, we based ourselves on probability distributions for key parameters, such as the production of plastics. Most of the other data were only available as single-point estimates. Additionally, the uncertainty of the weighting method itself was considered. By doing so, we considered the overall uncertainty margins on the EI-99 values to be +/−20%. Since the difference between the EI-99 of the one way cups is less than 20%, we consider it as not being significant. On the other hand, the eco-indicator value for the reusable PC cups, used at small events is significantly (50%) lower. The EI-99 values for the use of cups on large outdoor events are comparable for the four cup systems that have been studied.

For the basic scenario, the hierarchical perspective was chosen as a default method for the damage model. The egalitarian and the individualist perspective were respectively selected in two separate sensitivity analyses. When comparing the results of the hierarchical and the egalitarian perspective (long term) the conclusions about ranking from the eco-indicator part of the LCA remained the same for both the small indoor as well as the large outdoor events. So the results are, in this case, independent of the perspective.

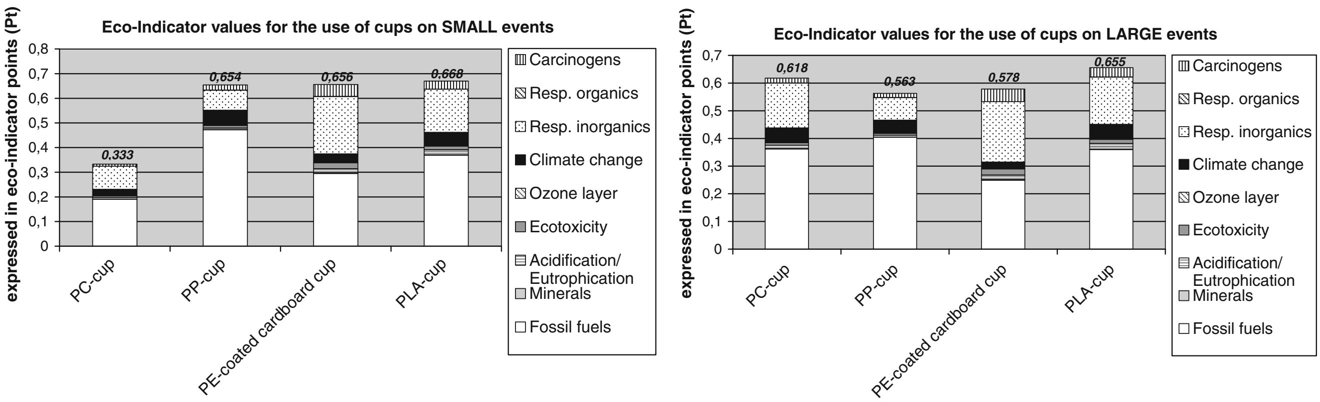

Fig. 4 Eco-indicator values for the use of cups at small-scale indoor and large-scale outdoor events, respectively, weighting according to hierarchical perspective

3.2 Calculation of the cost indicator

For the life cycle costing, we appealed to the definitions as described in (Hunkeler et al. 2008) which define three types of life cycle costing: (1) conventional LCC, (2) environmental LCC, and (3) societal LCC. All definitions have in common that all costs associated with the system as applied to the defined life cycle are taken into account. Because in this eco-efficiency study, the cost indicator needed to relate to the environmental indicator which is based on LCA, the cost indicator was calculated according to the environmental life cycle costing methodology. This approach is the most consistent with LCA and considers the complete life cycle of a product system from the perspective of one or more actors that are connected to the product life cycle.

For the calculation of the cost indicator, the viewpoint of event organisers was used as a starting point, added with some elements related to the end-of-life stage. For instance, if the waste is collected by the local authority at its own costs, these costs have been taken up in the cost analysis as well, because the waste collection stage lies entirely within the system boundaries. Furthermore it was assumed that all production costs of the cups were reflected in the price charged to the customer, i.e., the event organiser or the brewer (in order to be able to value “free” cups that are included in a package deal with the brewer). For the cost analysis, the question of adding up all cost data within the system boundaries was a lot easier than aggregating the environmental impacts. Costs are already expressed in the same units, Euros. Therefore, no weighting was needed. We considered an uncertainty margin for the single-score cost indicator to be +/−10%. This uncertainty margin stems from price differences between different suppliers as cost data were based on a sample survey amongst suppliers.

Figure 5 shows that in case of small indoor events, the PP cup system has the lowest cost indicator. The differences with the other one-way cup systems (cardboard and PLA cup system) and the reusable PC cup system are significant. The cost indicator of the PC cup system is significantly higher than the other cup systems. The cost indicator of the PC cup system is mainly determined by the rental price (40%), the lower drink consumption (33%), and

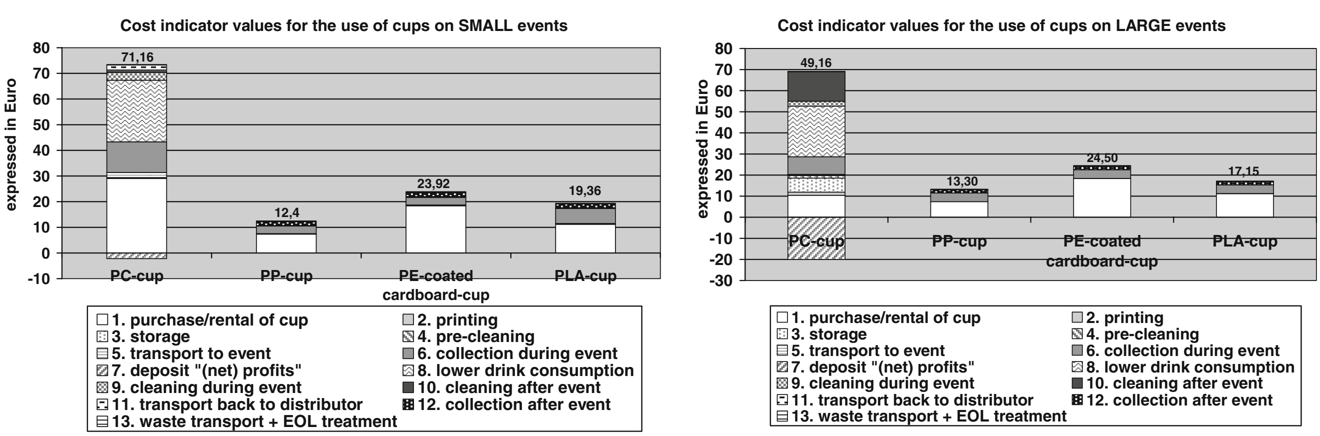

Fig. 5 Cost indicator values for the use of cups at small-scale indoor and large-scale outdoor events, respectively

the collection cost of the cups during the event (16%). The other factors are less dominant. A time series of data based on experiences of event organisers showed that the introduction of reusable PC cups during an event comprises a loss of income due to lower drink consumption. This data could not be confirmed by literature but was accepted during the review; however, can be regarded as a less stable data. The cost indicators of the one-way cup systems used at small events are mainly determined by the cost price of the cup (purchase) and to a lower extent by the costs related to the collection of the cups at the event site. For large outdoor events using PP cups, the costs are significantly lower compared to using the other one-way cups (PE coated cardboard and PLA cups) or the reusable PC cups. Although the cost indicator of the PC cup system used at large events is significantly higher than the other cup types, the absolute value is a factor 2 lower than the cost indicator that was calculated for small events. This is mainly caused by the fact that at large events more PC cups turn up as “waste”. From the viewpoint of the organisers, this means that all cups that are not returned to the collection point yield the organisers a benefit of 1 euro (net profit). This is visible in Fig. 5 by means of the negative value for the “deposit” step. The cost indicator of the PC cup system used at large events is mainly determined by the lower drink consumption (similar to small events), the net profit due to the deposit systems (because less PC cups are brought to the cash desk), the cleaning after the event (machine cleaning on different location) and the cost price (purchase, no rental for large events) of the cups itself. The other cost factors are less dominant. The cost indicators of the one-way cup systems used at large events are mainly determined by the cost price of the cup (purchase) and to a lower extent by the costs related to the collection of the cups at the event site. The cost indicators of the one-way cups used at small events are very much comparable to the cost indicators of the respective one-way cup systems at large events (Fig. 5). Only small differences appear.

4 Portfolio analysis of drinking cups used on events

4.1 Methodology

Eco-efficiency has been variously defined and analytically implemented by several researchers. In most cases, eco-efficiency is taken to mean the ecological optimization of overall systems while not disregarding economic factors (Von Weizsäcker and Seiler-Hausmann 1999). Eco-efficiency is the merging of product or service value and ecological aspects into an efficiency ratio. This means maximising value while minimising adverse environmental impact. If eco-efficiency is applied for decision making, it makes sense to separate both numerator and denominator data (Verfaille and Bidwell 2000). In this study, the environmental and cost indicator was combined in a portfolio analysis, per cup system.

An eco-efficiency (EE) portfolio presents both a single environmental score and an economic (cost) score in a two-dimensional graph. The way to present EE is not standardised yet. Several ways of scaling the axes in an EE portfolio exist in literature (Saling et al. 2002). Some methods set the average of all options in the centerpoint with coordinates (1,1) and calculate the relative scores as the ratio between the absolute and the average score. Other methods are based on the maximum scores. These relate the maximum cost and environmental indicator with the coordinates (1,0) respectively (0,1) and calculate the relative scores as the ratio between the absolute and the maximum score. Keeping in mind that these are just ways of presenting the data in a graph with the aim to give an overview, it does not really matter as long as it is clear what the units on the axes are. All methods have in common that only relative scores are calculated and shown in the graph, without dimensions on the axes. Evidently, the underlying scores nor their accuracy change by using these graphs. An analysis of different methods was presented and discussed during the 2nd Eco-Efficiency conference.

In this study, the objective was to focus on the differences and therefore scaling was based on both the average and the standard deviation of the values of all alternatives. The centerpoint of the graph represents the average value of all four options while the difference between an individual score is expressed in standard deviations. The size of the dots does not reflect a specific uncertainty. The uncertainty margins, for the eco-indicator as well as for the cost indicator, are graphically shown as the X and Y error bars in dotted lines. For the absolute cost indicator an uncertainty margin of +/−10% is taken into account (because of price differences among the suppliers). The absolute environmental indicators have an uncertainty margin of +/−20%, because of the uncertainty range of the inventory data in combination with the uncertainty range of the weighting methodology. These uncertainty margins are needed to show the significance of differences in cost and environmental indicator. For the portfolio, these uncertainty margins on absolute values were scaled.

In an EE portfolio as applied in this study, the most eco-efficient option has simultaneously the lowest cost and the lowest environmental score and vice versa. As a help for interpretation, a compass needle was added in the legend that indicates that whenever an option is located more in down left position compared to another option it is considered more eco-efficient, taking into account the significance of the difference.

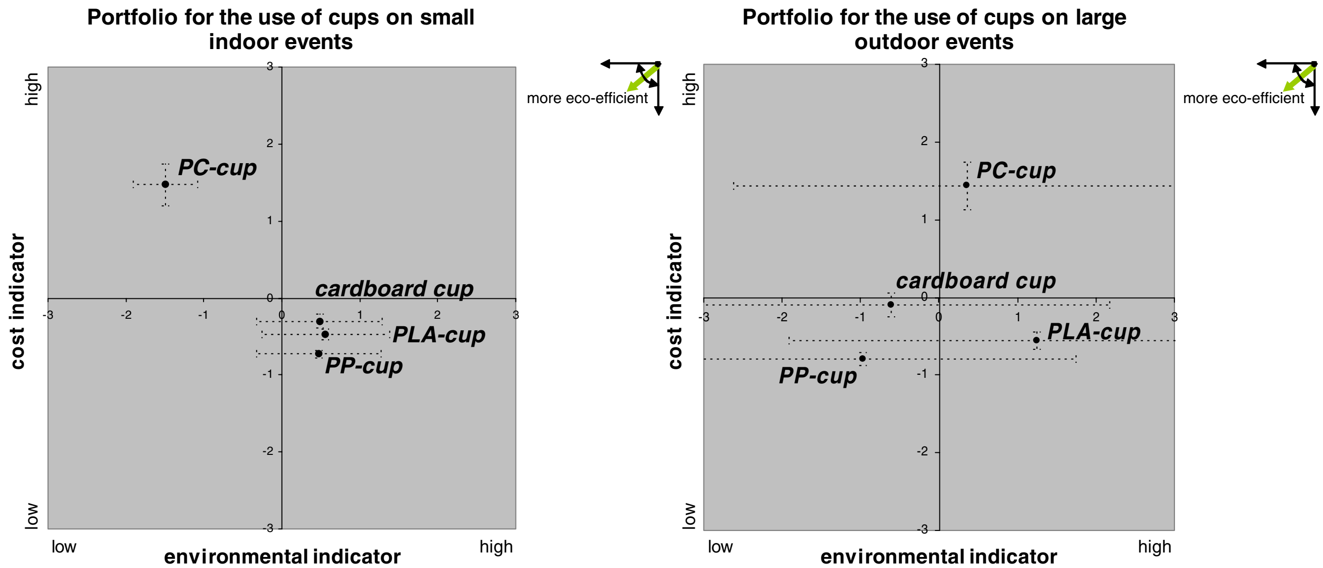

Fig. 6 Portfolio for the use of cups at small-scale indoor and large-scale outdoor events, respectively

Conclusions regarding the eco-efficiency of the options are based on both the environmental and the economic dimension individually but also in combination. In other words, options are considered to be most eco-efficient when both dimensions are better and considered to be least eco-efficient when both dimensions are worse. When the best environmental option simultaneously is the most expensive one, this does not lead to conclusions about whether the option is more, less or equally eco-efficient, but it does lead directly to environmental policy recommendations to consider the promotion of this option.

4.2 Results

Figure 6 shows the portfolio for the use of cups at small indoor events and large outdoor events according to the basic scenario. For the small indoor events, the portfolio shows clearly that the three one-way cups score approximately the same on environmental impact, but have significantly different cost indicator scores. The one-way PP cup demands the lowest costs from the viewpoint of the event organisers, followed by the PLA cup, and the cardboard cup. Compared to the one-way cups, the reusable PC cup causes a significantly lower environmental impact; however, combined with a significantly higher cost indicator. This high cost price for reusable cups does not initiate organisers to use reusable cups. From an environmental policy point of view, one could consider to promote the use of reusable PC cups at small indoor events.

For the large outdoor events, the four-cup systems do not differ significantly with regard to the environmental indicator values, taking account of the uncertainty areas. Although the portfolio for large events gives the impression that the uncertainty margin of the environmental indicator is

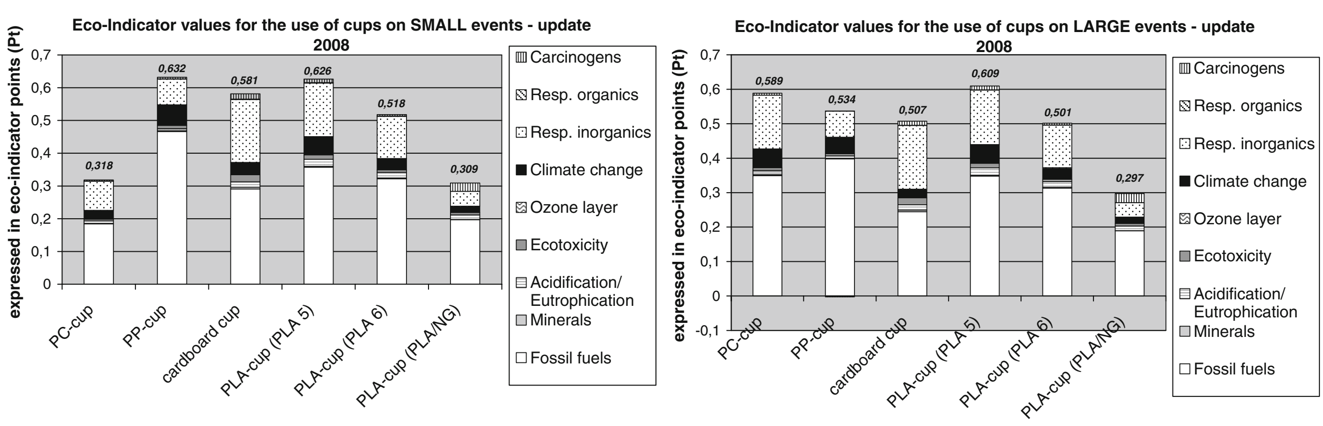

Fig. 7 Eco-indicator values for the use of cups at small-scale indoor and large-scale outdoor events, respectively, updated profile PLA6

high compared to small events, in absolute value the uncertainty margins are comparable between both types of events. The differences between the absolute environmental indicators of the four cup systems at large events are small and as such also the standard deviation (which is the unit for the axes) is small. This explains the wide uncertainty ranges in the portfolio presentation. The costs however show significant differences. The cost indicator value of the PP cup is significantly lower than the PLA, respectively, the cardboard cup. The costs related to the reusable PC cup are much higher than the costs of the one-way cups. However, due to the insignificant difference between the environmental impacts of all options, there is no reason for a promoting or discouraging policy of any of the cup types on large outdoor events.

This study was finalised in 2006, data relate as much as possible to 2005. The PLA material and the scale of its application was and is still changing rapidly. Now, already a new ecoprofile for PLA-production is published (Vink et al. 2007). We imported the latest data for PLA production (PLA 6-2,006 PLA production system) in our model. The results of the weighted profile are presented in Fig. 7. Small updates of databases and the Eco-Indicator 99 method lead to slightly other environmental values also for the other cup types. In the near future (within 1 or 2 years) the environmental score for the PLA cup system might improve significantly if the current trend continues (PLA/NG-next generation PLA production system). If this becomes reality, the policy of promoting the use of PC reusable cups should be reconsidered, taking into account all improvements that the other cup systems might achieve by that time.

5 Policy conclusions

This comparative LCA study according to ISO led to the conclusion that none of the four considered cup systems has overall superior or inferior performance neither at small nor large events since no cup system scores best or worst on all environmental impact categories. This means that there were no scientific arguments for a policy of encouraging or discouraging one of the four cup systems. A policy development would need subjective values in its decision process.

The eco-efficiency assessment (with its subjective weighting choices and inherent limitations, that the commissioner of the study should realise and support in the context of this study) showed that in the base case for small events, the reusable PC cup system shows a significant more favourable environmental score than the other three cup systems. As the costs of the reusable PC cup system are higher, a policy of promoting the system may be considered based on the more favourable environmental score. Policy makers should agree on the subjective value choices made while weighting different impact or impact categories.

This conclusion is relevant for small events, but could also apply to large events provided that the trip rate reaches a minimum level at which the environmental indicator for the reusable PC cup becomes significantly better than the one-way cups. This was called the ‘turning point’. Hence, another conclusion following from this study could be that policy could also stimulate event organisers towards actions that improve the trip rate at the event.

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